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TI **Tin** solder alloys
IN Yamashita, Mitsuo; Tada, Shinji; Shiokawa, Kunio
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AB The alloys contain >0-3.5 Sb, ≤3.0% **Ag**, and 1st and 2nd additives for improving the soldering properties. The 1st additives comprise **Cu** >0-1.0 and Ni >0-1.0%, and the 2nd additives comprise P >0-1.0 and Ge >0-1.0%. The alloys contain **Ag** >0-4.0, **Cu** >0-2.0, Ni >0-1.0, and P >0-1.0 and/or Ge >0-1.0%.

PATENT ABSTRACTS OF JAPAN

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(54) SOLDER

(57)Abstract:

PROBLEM TO BE SOLVED: To obtain a solder that dispenses with lead content causing a problem in environmental measures, that excels in heat resistance and thermal fatigue strength, and that enhances wettability and strength by using tin as the main component and adding a specific amount of antimony, silver, copper and nickel.

SOLUTION: The composition is designed to contain, in weight %, 2.5-3.5% antimony, 1.0-3.5% silver, 1.0% or less copper or nickel, and the remainder to be tin. This solder has a melting point of 232-240°C, with enhanced thermal fatigue property and with silver for the improvement in wettability of tin- antimony alloy; since the addition of silver causes lowering of the melting point, it is compensated by adding nickel and raising the melting point. The addition of copper is 1% or less, improving heat resistance and strength without impairing wettability, while its addition in excess will cause a rapid rise in the melting point. Similarly, the addition of nickel with 1.0% or less improves wettability, strength and thermal stability, but the excess addition will lower rolling workability, so that its content is confined within the above range.

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CLAIMS

[Claim(s)]
[Claim 1] tin -- a principal component -- carrying out -- antimony -- 2.5 thru/or 3.5 % of the weight, and silver -- 1.0 thru/or 3.5 % of the weight, and copper -- 1.0 or less % of the weight of ****** "a solder."
[Claim 2] tin -- a principal component -- carrying out -- antimony -- 2.5 thru/or 3.5 % of the weight, and silver -- 1.0 thru/or 3.5 % of the weight, and nickel -- 1.0 or less % of the weight of ****** "a solder."

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention relates to good "solder" of opposite environment nature without starting the "solder" used for junction of the metal in electronic equipment, especially containing lead.
[0002]
[Description of the Prior Art] When "joining by solder", as a required property, it has a desired virtual junction temperature, and that "wettability" is good, that thermal fatigue reinforcement and corrosion resistance are excellent, and not to contain Lead Pb from the consideration to an environment further are desired at the time of junction. The "solder" joint of the chip in a semiconductor device is area junction to a metallic conductor, since a big heat strain is generated by the heat release of the chip at the time of power energization, the "solder" used for a joint will be put on a severe operating environment, and the outstanding thermal fatigue reinforcement is required. Furthermore depending on a semiconductor device, "a soldered joint" of multiple times may be needed structurally, at this time, the "solder" of two or more classes from which virtual junction temperature differs is required, and the "solder" which cannot be easily influenced of the temperature profile of a back process is needed.
[0003] As conventional "solder" to these demands, it is Pb-Sn. A "solder" and Sn-Sb The "solder" is known. However, there were the following problems in the conventional "solder." Pb-Sn Tensile strength is low, since a "solder" is rich in ductility, its amount of generating strains is large, fatigue strength is low [a solder], and it has the fault that thermal fatigue reinforcement is low, together with the point that thermal resistance is low so that it may describe below. Pb-Sn Although a "solder" is an alloy which makes 183 ** eutectic temperature and the increment in Pb can raise a melting point to near 300 ** from 183 **, the solid-liquid coexistence field between the liquid phase temperature in which only the liquid phase exists, and the solid phase temperature (183 **) in which only solid phase exists becomes large. even if it is high Pb(s) "a solder" other than an eutectic presentation (63Pb37Sn) -- the coagulation time at the time of junction -- usually -- short -- duality high Pb-low [Sn] "a solder" -- it is few, the phase, eutectic structure, etc. where lead, tin, and each concentration are high turn into a metal texture of a gestalt variously, and it is hard to stabilize following an ideal coagulation process based on a system state diagram. Moreover, in respect of thermal resistance, since eutectic temperature is 183 **, there is a problem of being comparatively easy to produce quality-of-the-material degradation in a low-temperature region.
[0004] Furthermore, it is Pb-Sn. Since a "solder" contains Pb, it is not desirable in respect of an environmental cure.
[0005]
[Problem(s) to be Solved by the Invention] Pb-Sn Sn-Sb which does not contain Pb by the "solder" replaced with a "solder", and has melting point 232-245 ** as heat-resistant good "solder" The "solder" is known widely. Drawing 4 is Sn-Sb. It is the state diagram showing the phase equilibrium of a "solder."
[0006] This state diagram is the Japan Institute of Metals. It is a thing carried at a metal data book (Showa 49 editions). Sn-Sb A "solder" is Pb-Sn. Reinforcement is comparatively highly superior to the "solder." Sn-Sb A "solder" has a peritectic point (peritectic temperature of 245 degrees C) in Sb8.5wt%, and Sb is usually 8 wt%. It is used below. Since melting is produced between melting point 232 ** of Sn, and peritectic temperature 245 **, a solid-liquid coexistence field is narrow, melting initiation temperature is high, and it excels in thermal resistance. What was excellent also in reinforcement is obtained by increasing the amount of Sb(s). However, Sn-Sb The wettability of the "solder" at the time of a soldered joint was bad, and it was not what can also fully

satisfy thermal fatigue reinforcement.
[0007] This invention is made in view of an above-mentioned point, and that purpose is Sn-Sb. Sn-Sb which adds amelioration to a "solder", and wettability is good and is excellent in thermal fatigue reinforcement It is in offering a system "a solder."
[0008]
[Means for Solving the Problem] according to this invention in the above-mentioned purpose -- tin -- a principal component -- carrying out -- antimony -- 2.5 thru/or 3.5 % of the weight, and silver -- 1.0 thru/or 3.5 % of the weight, and copper -- 1.0 or less % of the weight of ****** -- a thing or tin -- a principal component -- carrying out -- antimony -- 2.5 thru/or 3.5 % of the weight, and silver -- 1.0 thru/or 3.5 % of the weight, and nickel -- 1.0 or less % of the weight of ****** -- it is attained by things.
[0009] Sn-Sb In a "solder", although Sb is added and the thermal fatigue property is raised in 240 ** from melting point 232 **, addition of Ag, Cu, and nickel attains an improvement of wettability and much more increment on the strength. Addition of Ag improves fatigue strength and wettability. Ag exists in the grain boundary at high concentration, and its fatigue strength improves in order to suppress migration of the grain boundary. However, Sn-Ag It sets to Sn-3.5wt% Ag and an alloy is the eutectic point (eutectic temperature 221 **). Since it has and the fall of a melting point is brought about by Ag addition, they are Cu and nickel. Addition can raise a melting point and the fall of a melting point can be compensated. as Ag addition -- 3wt% and 6wt% -- with the alloy to contain, reinforcement is this level. If Ag addition exceeds 3.5wt(s)%, a melting point (liquid phase temperature) becomes high, it is necessary to make it high and a solid-liquid coexistence field will benefit wettability reservation of virtual junction temperature large further.
[0010] Without spoiling wettability, addition of Cu dissolves in Sn and raises thermal resistance and alloy reinforcement. Cu -- more than 3wt% -- if it adds, the amount of formation of intermetallic compounds (Cu3Sn etc.) will increase as a melting point (liquid phase temperature) rises rapidly and is pointed out to JP,5-50286,A, and fatigue strength will be spoiled. Cu -- 0.5wt(s)% -- even if it adds, improvement in reinforcement is brought about.
[0011] Addition of nickel is the detailed-ized effectiveness of the crystalline structure, and nickel-Sn while bringing about the thermal stability of an alloy by one with a high (1450 degrees C) melting point. Generation of the intermetallic compound (Cu3Sn) to which the bonding strength at the time of joining to the improvement effectiveness in a thermal fatigue property by formation of a compound and Cu substrate is reduced is controlled. If the amount of nickel increases (more than 5wt%), an alloy ingot becomes difficult, at the time of junction, viscosity will become large and breadth nature will fall. The amount of nickel is 1.0 wt%. Below, the improvement in on the strength and wettability improve. If the amount of nickel exceeds 1wt %, it will become hard and rolling workability will worsen.
[0012]
[Embodiment of the Invention] A "solder" uses tin as a principal component. Antimony 2.5 thru/or 3.5 % of the weight, They are 1.0 thru/or 3.5 % of the weight, and copper about silver 1.0 or less % of the weight of ****** Sn-Sb A system "a solder" and tin are used as a principal component. For antimony silver 2.5 thru/or 3.5% of the weight 1.0 thru/or 3.5 % of the weight, It is nickel 1.0 or less % of the weight of ****** Sn-Sb A system "a solder" or tin is used as a principal component. They are [antimony] 1.0 or less % of the weight of an amount, and nickel about 1.0 thru/or 3.5 % of the weight, and copper in 2.5 thru/or 3.5 % of the weight, and silver 1.0 or less % of the weight of ****** Sn-Sb A system "a solder" is used.
[0013] drawing 1 -- Sn, Sb, Ag, and Cu from -- it is the important section expansion regular-tetrahedron Fig. showing the becoming optimal presentation field of a "solder." drawing 2 -- Sn, Sb, Ag, and nickel from -- it is the important section expansion regular-tetrahedron Fig. showing the becoming optimal presentation field of a "solder." drawing 3 -- Sn, Sb, Ag, and nickel+Cu from -- it is the important section expansion regular-tetrahedron Fig. showing the becoming optimal presentation field of a "solder."
[0014] the optimal presentation fields are f1, f2, f3, f4, f5, f6, f7, f8 or f1, f2, f3, f4, f9 and f10, f11, f12, and a field come out of and surrounded in this drawing. however, f1, f2, f3, f4, and the flat surface come out of and surrounded are not included. It is n 1 Or when considering as the integer of 12 fn (Sb % of the weight and Ag weight % and Cu weight %, nickel weight % or (Cu+nickel) weight %, and Sn weight %) The "solder" presentation in a regular tetrahedron is shown. Metaled weight % is the height of a regular tetrahedron 100 When it carries out, it is the die length of the perpendicular given to four flat surfaces from each presentation. (Cu+nickel) For weight %, Cu and each nickel are 1.0. It is below weight %.

[0015] f1 (2. 5, 1.0, 0, 96.5) and f 2 (3. 5, 1.0, 0, 95.5), f3 (0 3. 5, 3.5, 93.0) and f 4 (2. 5, 3.5, 0, 94.0), f5 (2. 5, 1.0, 1.0, 95.5) and f6 (3. 5, 1.0, 1.0, 94.5), f7 (3. 5, 3.5, 1.0, 92.0), f8 (2. 5, 3.5, 1.0, 93.0), f9 (2. 5, 1.0, 2.0, 94.5) and f10 (3. 5, 1.0, 2.0, 93.5), f11 (3. 5, 3.5, 2.0, 91.0) and an f12(2. 5, 3.5, 2.0, 92.0) "solder" are produced by dissolving Sn, Sb, Ag, Cu, and nickel each raw material metal in an electric furnace.
[0016]
[Example] The metal beyond purity 99.99wt% was used for the experiment. This ingot raw material was cast to metal mold, and the piece of a tensile test (3 mmphi) was produced, and wettability was measured using some ingot raw materials. The tension test was carried out at the room temperature. Wettability is meniscography and was measured using flux (RMA type). It heated, melting of the solder raw material was carried out to 280 **, the copper wire of 2 mmphi was used, and the wetting force was measured after immersion.
[0017] Elongation after fracture and the wetting force are shown in Table 1 in the melting point of alloy each presentation, and tension strength. The figure which shows the presentation of front Naka expresses weight %.
[0018]
[Table 1]

Sb	Ag	Cu	Ni	Sn	溶融点 (℃)	引っ張り強さ (kg/mm²)	伸び (%)	ぬれ力 (mN)
8	–	–	–	残		4. 1 1	4 3	1.2
7	–	–	–	残		4. 3 1	4 7	
5	–	–	–	残	243/235	2. 4 2	8 4	1.24
4	–	–	–	残		2. 7 3	4 4	1.27
3	–	–	–	残	240/235	1. 2 1	1 3 7	1.32
3	–	0.5	–	残		2. 3 6	2 5	1.39
3	–	1	–	残	235/230	3. 6 4	4 5	1.33
3	–	–	0.5	残		3. 5 3	1 8	1.51
3	1	–	0.2	残		6. 0 4	3 4	1.33
3	1	0.5	0.2	残		5. 3 4	1 4	1.3
3	1	1	–	残	233/222	5. 3 4	3 2	1.33
3	1	1	0.5	残	232/220	4. 7 3	2 1	1.45
3	1	1	1	残	234/220	4. 4 8	2 0	1.45
3	3	–	0.5	残	231/225	7. 1 3	1 7	1.48
3	3	0.5	0.2	残		7. 0 4	1 7	1.5
3	3	0.5	0.5	残	229/220	7. 1 4	1 6	1.5
3	6	0.5	–	残	226/220	6. 3 6	2 9	1.38
3	6	–	0.5	残	230/224	5. 9 7	1 0	1.5
3	6	0.5	0.5	残	228/221	6. 6 7	8	1.51

[0019] Sn-Sb Although tensile strength will increase if the amount of Sb(s) in an alloy is increased, wettability has the inclination to fall. An increment of Ag addition accepts improvement in reinforcement. however, the increment in level on the strength -- Ag -- 3wt(s)% -- even if it adds -- 6 wt% Even if it adds, it is this level mostly. Ag is effective in improving wettability without falling a melting point greatly, but if 3.5wt% is exceeded, melting temperature (liquidus line) will rise, it will be necessary to make working temperature high, and a solid-liquid coexistence temperature region with eutectic temperature 221 ** (solidus line) will also become large. Therefore, the addition of suitable Ag which raises reinforcement and makes wettability improve is the amount of 1 -3.5wt%.
[0020] When Cu and nickel are added to Sn-3wt% Sb, since reinforcement improves, it turns out that the strengthening effectiveness is brought about. Sn-3wt%Sb-1wt%Ag-1wt%Cu nickel -- 0.5wt(s)% and 1.0wt% -- it turns out that what was added shows the outstanding wettability and wettability improves with the improvement in on the strength by compound addition. moreover, Sn-3%wtSb-3wt%Ag -- setting -- Cu and nickel 0.5wt(s)% -- what was added -- reinforcement – most -- high -- wettability -- Sn-5 wt%Sb "Solder" Sn-8 wt%Sb It excels as compared with the "solder." Sn-3wt%Sb Reinforcement is a "solder" 3 to 5 times by carrying out compound addition of 3 wt% Ag, 0.5wt%Cu, and the 0.5wt%nickel. Cu and nickel Although effectiveness is in the improvement in on the strength even if it adds independently, the direction which carried out compound addition is useful to improvement in thermal fatigue reinforcement.

[0021] Sn-Sb Although it was the description for an alloy to have a melting point in the range of 230-245 **, and to excel in strength in high temperature, it was a fault that it is inferior to wettability. it compares with Sn-Sb "a solder" which contains Sb beyond 4wt% by adding Ag, Cu, and nickel, and in reinforcement, it is markedly alike, excels, and has thermal resistance so that the measurement result obtained in the above example may show, and the "solder" whose wettability also improved is obtained.
[0022]
[Effect of the Invention] According to this invention, a "solder" uses tin as a principal component. Antimony 2.5 thru/or 3.5 % of the weight, Make copper into 1.0 or less % of the weight of ****** for silver 1.0 thru/or 3.5% of the weight, or use tin as a principal component, and 2.5 thru/or 3.5% of the weight, since 1.0 thru/or 3.5 % of the weight, and nickel are made into 1.0 or less % of the weight of ****** for silver, antimony Sn-Sb containing Sb beyond 4wt% It compares with a "solder", and in reinforcement, it is markedly alike, excels, and has thermal resistance, and the "solder" whose wettability also improved was obtained. Moreover, since this alloy did not contain lead, the "solder" desirable also in environment was obtained.

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TECHNICAL FIELD

[Field of the Invention] This invention relates to good "solder" of opposite environment nature without starting the "solder" used for junction of the metal in electronic equipment, especially containing lead.

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PRIOR ART

[Description of the Prior Art] When "joining by solder", as a required property, it has a desired virtual junction temperature, and that "wettability" is good, that thermal fatigue reinforcement and corrosion resistance are excellent, and not to contain Lead Pb from the consideration to an environment further are desired at the time of junction. The "solder" joint of the chip in a semiconductor device is area junction to a metallic conductor, since a big heat strain is generated by the heat release of the chip at the time of power energization, the "solder" used for a joint will be put on a severe operating environment, and the outstanding thermal fatigue reinforcement is required. Furthermore depending on a semiconductor device, "a soldered joint" of multiple times may be needed structurally, at this time, the "solder" of two or more classes from which virtual junction temperature differs is required, and the "solder" which cannot be easily influenced of the temperature profile of a back process is needed.
[0003] As conventional "solder" to these demands, it is Pb-Sn. A "solder" and Sn-Sb The "solder" is known. However, there were the following problems in the conventional "solder." Pb-Sn Tensile strength is low, since a "solder" is rich in ductility, its amount of generating strains is large, fatigue strength is low [a solder], and it has the fault that thermal fatigue reinforcement is low, together with the point that thermal resistance is low so that it may describe below. Pb-Sn Although a "solder" is an alloy which makes 183 ** eutectic temperature and the increment in Pb can raise a melting point to near 300 ** from 183 **, the solid-liquid coexistence field between the liquid phase temperature in which only the liquid phase exists, and the solid phase temperature (183 **) in which only solid phase exists becomes large. even if it is high Pb(s) "a solder" other than an eutectic presentation (63Pb37Sn) -- the coagulation time at the time of junction -- usually -- short -- duality high Pb-low [Sn] "a solder" -- it is few, the phase, eutectic structure, etc. where lead, tin, and each concentration are high turn into a metal texture of a gestalt variously, and it is hard to stabilize following an ideal coagulation process based on a system state diagram. Moreover, in respect of thermal resistance, since eutectic temperature is 183 **, there is a problem of being comparatively easy to produce quality-of-the-material degradation in a low-temperature region.
[0004] Furthermore, it is Pb-Sn. Since a "solder" contains Pb, it is not desirable in respect of an environmental cure.
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EFFECT OF THE INVENTION

[Effect of the Invention] Since according to this invention a "solder" uses tin as a principal component, and copper is made [antimony] into 1.0 or less % of the weight of ****** for silver 1.0 thru/or 3.5% of the weight 2.5 thru/or 3.5% of the weight, or tin is used as a principal component and nickel is made [antimony] into 1.0 or less % of the weight of ****** for silver 1.0 thru/or 3.5% of the weight 2.5 thru/or 3.5% of the weight Sn-Sb containing Sb beyond 4wt% It compares with a "solder", and in reinforcement, it is markedly alike, excels, and has thermal resistance, and the "solder" whose wettability also improved was obtained. Moreover, since this alloy did not contain lead, the "solder" desirable also in environment was obtained.

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TECHNICAL PROBLEM

[Problem(s) to be Solved by the Invention] Pb-Sn Sn-Sb which does not contain Pb by the "solder" replaced with a "solder", and has melting point 232-245 ** as heat-resistant good "solder" The "solder" is known widely. Drawing 4 is Sn-Sb. It is the state diagram showing the phase equilibrium of a "solder."
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[0007] This invention is made in view of an above-mentioned point, and that purpose is Sn-Sb. Sn-Sb which adds amelioration to a "solder", and wettability is good and is excellent in thermal fatigue reinforcement It is in offering a system "a solder."

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EXAMPLE

[Example] The metal beyond purity 99.99wt% was used for the experiment. This ingot raw material was cast to metal mold, and the piece of a tensile test (3 mmphi) was produced, and wettability was measured using some ingot raw materials. The tension test was carried out at the room temperature. Wettability is meniscography and was measured using flux (RMA type). It heated, melting of the solder raw material was carried out to 280 **, the copper wire of 2 mmphi was used, and the wetting force was measured after immersion.
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[Table 1]

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8	–	–	–	残		4.11	43	1.2
7	–	–	–	残		4.31	47	
5	–	–	–	残	243/235	2.42	84	1.24
4	–	–	–	残		2.73	44	1.27
3	–	–	–	残	240/235	1.21	137	1.32
3	–	0.5	–	残		2.36	25	1.39
3	–	1	–	残	235/230	3.64	45	1.33
3	–	–	0.5	残		3.53	18	1.51
3	1	–	0.2	残		6.04	34	1.33
3	1	0.5	0.2	残		5.34	14	1.3
3	1	1	–	残	233/222	5.34	32	1.33
3	1	1	0.5	残	232/220	4.73	21	1.45
3	1	1	1	残	234/220	4.48	20	1.45
3	3	–	0.5	残	231/225	7.13	17	1.48
3	3	0.5	0.2	残		7.04	17	1.5
3	3	0.5	0.5	残	229/220	7.14	16	1.5
3	6	0.5	–	残	226/220	6.36	29	1.38
3	6	–	0.5	残	230/224	5.97	10	1.5
3	6	0.5	0.5	残	228/221	6.67	8	1.51

[0019] Sn-Sb Although tensile strength will increase if the amount of Sb(s) in an alloy is increased, wettability has the inclination to fall. An increment of Ag addition accepts improvement in reinforcement. however, the increment in level on the strength -- Ag -- 3wt(s)% -- even if it adds -- 6 wt% Even if it adds, it is this level mostly. Ag is effective in improving wettability without falling a melting point greatly, but if 3.5wt% is exceeded, melting temperature (liquidus line) will rise, it will be necessary to make working temperature high, and a solid-liquid coexistence temperature region with eutectic temperature 221 ** (solidus line) will also become large. Therefore, the addition of suitable Ag which raises reinforcement and makes wettability improve is the amount of 1 -3.5wt%.
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it turns out that what was added shows the outstanding wettability and wettability improves with the improvement in on the strength by compound addition. moreover, Sn-3%wtSb-3wt%Ag -- setting -- Cu and nickel 0.5wt(s)% -- what was added -- reinforcement -- most -- high -- wettability -- Sn-5 wt%Sb "Solder" Sn-8 wt%Sb It excels as compared with the "solder." Sn-3wt%Sb Reinforcement is a "solder" 3 to 5 times by carrying out compound addition of 3 wt% Ag, 0.5wt%Cu, and the 0.5wt%nickel. Cu and nickel Although effectiveness is in the improvement in on the strength even if it adds independently, the direction which carried out compound addition is useful to improvement in thermal fatigue reinforcement.

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DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] Sn, Sb, Ag, and Cu from -- important section expansion regular-tetrahedron Fig. showing the becoming optimal presentation field of a "solder"
[Drawing 2] Sn, Sb, Ag, and nickel from -- important section expansion regular-tetrahedron Fig. showing the becoming optimal presentation field of a "solder"
[Drawing 3] Sn, Sb, Ag, the important section expansion regular-tetrahedron Fig. showing the optimal presentation field of a "solder" which consists of nickel+Cu
[Drawing 4] Sn-Sb State diagram showing the phase equilibrium of a "solder"

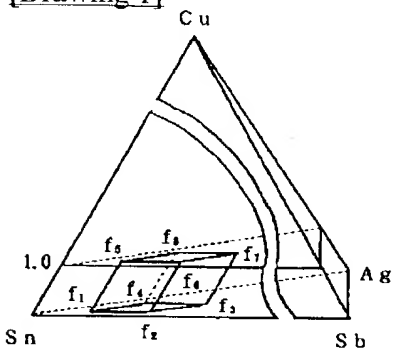
[Translation done.]

* NOTICES *

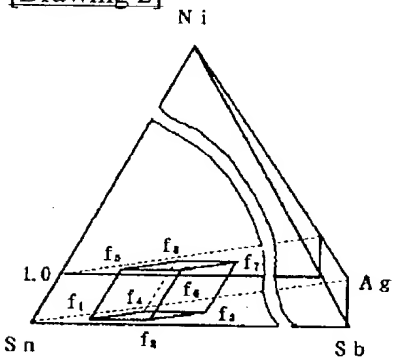
1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DRAWINGS

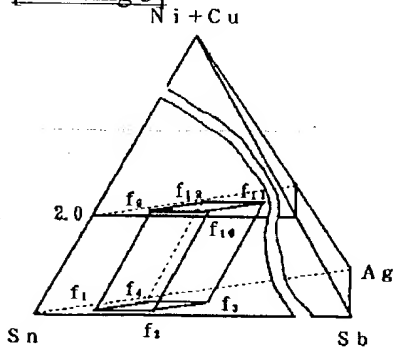
[Drawing 1]



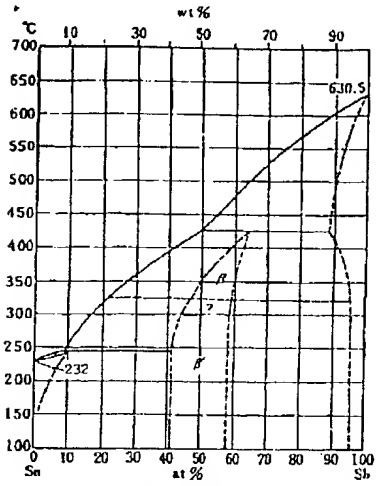
[Drawing 2]



[Drawing 3]



[Drawing 4]



Sn-Sb

[Translation done.]